Preparation for Lab on Regulating Greenhouse Gas Emissions

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Introduction

For the laboratory period on Monday November 5, we will do a role-playing exercise explore the effectiveness of three different approaches to regulating pollution, such as greenhouse gas emissions: command-and-control, cap-and-trade, and emissions taxes. This reading should serve to prepare you for the exercise.

Zero-Emissions Baseline

The handout "The economics of regulating greenhouse gas emissions" uses a baseline scenario of business-as-usual emissions and calculates the costs and benefits of an alternate policy that cuts emissions below this baseline. This is the usual way policy analysts examine regulations, but if we did the emissions-trading game this way, it would be more confusing. To simplify things, we'll do the emissions-trading game a different way: with a zero-emissions baseline that will allow us to calculate costs and benefits of emitting CO_2. In this case, the costs to the players will be the cost of buying permits to emit CO_2 and the benefits will be the profits they earn. The costs to society will be the social cost of carbon (the damage caused by global warming) and the benefit will be the combination of profit earned by the companies (this benefits the companies, but it's also part of the gross domestic product of the nation) and money received from the players as taxes or payment for emissions permits.

The Exercise

The Players

To keep groups small, I will divide the class in half and each half will perform the same role-playing exercise. For the exercise, I will divide the students into three groups:

1. One group will play The Environmental Protections Agency (EPA) and will decide how much to reduce pollution, how many permits to issue, or how much to charge as a pollution tax.

   The EPA's motivation is to produce the best net benefit for society by balancing the costs of reducing greenhouse gas emissions against the benefits of limiting global warming.

2. A second group will play Alpha Electricity: a large power company with a varied portfolio of generating plants including coal, natural gas, and nuclear.

Alpha's motives are purely to produce the greatest profit for its shareholders regardless of the cost to society of greenhouse gas emissions.

3. A third group will play Beta Industries: a large heavy-industrial conglomerate with many large factories producing steel, aluminum, and petrochemicals such as plastics, paints, and pharmaceuticals.

   Beta's motives are purely to produce the greatest profit for its shareholders regardless of the cost to society of greenhouse gas emissions.

For the purposes of this exercise, we will assume that the EPA can accurately estimate the damage that would be caused by global warming, and thus, that it can also accurately estimate the social benefit of reducing greenhouse gas emissions. However, the EPA cannot accurately assess the costs individual companies will incur when they reduce their emissions. This means that the EPA's estimates of net benefits (benefits minus costs) is limited by its uncertainty about the cost of reducing emissions.

Only the EPA will know the social cost of greenhouse gas emissions, only Alpha will know Alpha's cost for reducing emissions, and only Beta will know Beta's cost for reducing emissions.

Without regulation, Alpha and Beta would each emit 150 million tons of CO_2 per year. The goal of the exercise is for the EPA to reduce pollution to achieve the socially optimal balance between the benefits of economic activity (jobs, wealth, etc.) and the harms of pollution. The goal of each firm is to maximize their profit regardless of the costs or benefits to society or to its competitor.

To keep things simple, emissions cuts will be figured in blocks of 10 million tons, so a firm can cut emissions by zero, 10 million tons, 20 million tons, . . . , up to a maximum of 150 million tons (cutting emissions by 150 million tons means the firm reduces its emissions to zero).

The Game

The game will have six stages:

1. First, the EPA will gather information on the cost of abating pollution. A representative of the EPA can ask four questions about each company's costs (I recommend asking questions about the marginal profit for the n^{th} million tons of pollution, or how much it would cost to reduce emissions by x million tons.). A representative of each company will answer the question. The representatives may answer strategically, meaning they may exaggerate the costs. The EPA may take this into account in deciding how to use the answers to estimate the true cost of reducing emissions.
2. Second, the EPA will determine three possible courses of action:
   a) A command and control regulation, which mandates a specific emissions reduction. Because the Constitution guarantees equality before the law, this regulation must impose the same emissions cut for each firm.[1]
   b) A cap-and-trade. Under this program, the total emissions cuts would be the same and the EPA will issue permits to emit CO_2. Each permit will allow the owner to emit 10 tons of CO_2. Total CO_2 emissions are 300 million tons minus the emissions cuts the EPA wants to impose. If the EPA wants to cut emissions by 200 million tons, it would issue 10 permits (300 million $-$ 20 $\times$ 10 million $=$ 100 million; Each permit allows 10 million tons of emissions so 100 million/10 million $=$ 10 permits). Again, to keep things simple, make the number of permits a multiple of 2. The EPA will give each company an equal number of permits (if the EPA issues 10 permits, it gives 5 to each company).
   c) An emissions-tax program. Under this program, the EPA determines the tax a firm must pay for every million tons of CO_2 it emits. The firms will then decide on their own how much to cut their emissions.
3. Third, the firms determine how much CO_2 they will emit under the command-and-control program (this is easy). At the end of this round, the EPA will publish the total benefit to society of the emissions reduction, the firms will calculate their total costs (but keep these secret), and the instructor will announce the total deadweight loss due to inefficiencies in the regulation.
4. Fourth, permits will be distributed. The class will vote whether to auction the permits and distribute them to the highest payer or give equal numbers of permits to each firm and allow the firms to trade permits with each other. After the permits are allocated, we will again announce the total benefits to society and the deadweight loss.
5. Fifth, we will impose an carbon tax, at the price set by the EPA in stage 2. The two firms will be free to cut emissions by as much or as little as they want (between 0 and 150 million tons each). After each firm determines its final emissions, we will once again announce the total benefits to society and the deadweight loss.
6. Sixth and finally, we will reveal the details at each step, including the private information each firm has about its costs. This will let us discuss and analyze the strengths and limitations of each regulatory program.

Acknowledgements

This exercise was adapted from The Pollution Game, an interactive exercise developed by Jay R. Corrigan, Associate Professor of Economics, Kenyon College.
See J.R. Corrigan, "The Pollution Game: A Classroom Exercise Demonstrating the Relative Effectiveness of Emissions Taxes and Tradable Permits,'' *The Journal of Economic Education* **42**, 70–78 (2011) doi: 10.1080/00220485.2011.536491

[1] The real world is a bit more complex, because the government would be allowed to regulate different industries differently, but would face real obstacles if it tried to impose different emissions cuts on different companies within the same industry. Because this exercise is limited to just two companies, we simplify by forcing the EPA to impose identical emissions cuts on all firms.} Based on what it knows about the costs (to the firms) and benefits (to society) of reducing emissions, the EPA will determine how many million tons of total emissions to cut (to keep things simple, the EPA should make the amount an even multiple of 20 million tons). It will then divide those emissions cuts equally between the two firms.

Homework

Do the following homework (turn it in on Monday November 5 at the beginning of lab):

1. Table 1 lists the marginal profit a company earns by emitting CO_2. Fill in the blanks in the table to show the total profits it earns at each amount of CO_2 emissions.
2. What level of CO_2 emissions would produce the maximum total profit? How much profit would this be?
3. If the company is emitting the amount of CO_2 that would maximize its profits, and then the Environmental Protection Agency requires the company to reduce its emissions by 5 million tons, what is the total cost for the company to comply with the regulation?
4. What is the marginal cost to comply with the regulation? (Be careful and consider, if the company cuts 1 million tons, then a second million tons, and so forth, what did it cost the company to make the fifth million-ton cut?)
5. If the EPA imposed a tax of \$30 per ton on CO_2 emissions, complete the table to indicate the new marginal profit and total profit at each level of emission.
6. Under a \$30 per ton tax, what level of CO_2 emissions would produce the maximum total profit? What would its total profit be? How much less is this than the total profit you reported in question 2?
7. Table 2 shows the economic value of the marginal environmental harm caused by each additional million tons of CO_2 emissions. Fill in the blanks to indicate the total environmental harm.
8. The marginal net economic impact is the marginal profit generated by emitting each million tons of CO_2 minus the marginal environmental harm. This number is the net benefit to society from emitting an additional million tons of CO_2. If the number is positive, society benefits. If it is negative, society suffers.

   Fill in the marginal and total economic impacts, using the information on environmental harm from Table 2 and the information on marginal profits from Table 1.
9. What is the optimum amount of CO_2 to emit if we consider the net benefit to society (i.e., the net economic impact).

10. If you were going to set a cap on emissions, how many tons would you set the cap at?

11. If you were going to set a tax on emissions, how many dollars per ton would you set the tax at?

Table 1: Profits vs. Emissions

```
## Warning: funs() is soft deprecated as of dplyr 0.8.0
## Please use a list of either functions or lambdas:
##
##   # Simple named list:
##   list(mean = mean, median = median)
##
##   # Auto named with `tibble::lst()`:
##   tibble::lst(mean, median)
##
##   # Using lambdas
##   list(~ mean(., trim = .2), ~ median(., na.rm = TRUE))
## This warning is displayed once per session.
```

	No Emissions Tax		$30/ton Emissions Tax	
CO_2 Emissions (million tons)	Marginal profit (million dollars)	Total profit (million dollars)	Marginal profit (million dollars)	Total profit (million dollars)
1	85	$85	$85 - $30 = $55	$55
2	79	$79 + $85 = $164	$79 - $30 = $49	$49 + $55 = $104
3	73	$73 + $164 = $237	$73 - $30 = $43	$43 + $104 = $147
4	67			
5	61			
6	55			
7	49			
8	43			
9	37			
10	31			
11	25			
12	19			
13	13			
14	7			
15	1			
16	-5			
17	-11			
18	-17			
19	-23			
20	-29			

Table 1: Profits versus emissions: The table lists the marginal profit, in millions of dollars, for each million tons of CO_2 it emits. For instance, if it emits one million tons, it earns a marginal profit of $85 million. The total profit for x million tons is the sum of the marginal profits for each million tons from 1 to x.

Fill in the blanks with the total profit the company earns by for each amount of CO_2 emission."

Table 2: Environmental Harm vs. Emissions

	Environmental Harm		Net Economic Impact	
CO_2 Emissions (million tons)	Marginal harm (million dollars)	Total harm (million dollars)	Marginal impact (million dollars)	Total impact (million dollars)
1	5	$5	$85 - $5 = $80	$80
2	10	$10 + $5 = $15	$79 - $10 = $69	$149
3	15	$15 + $15 = $30	$73 - $15 = $58	$207
4	20			
5	25			
6	30			
7	35			
8	40			
9	45			
10	50			
11	55			
12	60			
13	65			
14	70			
15	75			
16	80			
17	85			
18	90			
19	95			
20	100			

Table 2: Economic impacts of CO_2 emissions. The table lists the marginal environmental harm, in millions of dollars, for each million tons of CO_2 released into the environment. For instance, the first million tons of emissions cause $5 million in damage.

The right pair of columns shows the net economic impact of the profits generated from the emissions (see Table 1) minus the environmental harm.

Fill in the blanks with the total environmental harm from CO_2 emission and compute the net economic impact.